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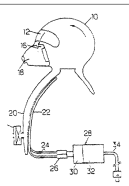
(54) Individual protective breathing equipment

(57) An individual protective breathing equipment, capable of ensuring NBC protection, comprising a head covering (10) delimiting a space which is separated from the outside all around the head and a mask for isolating the respiratory passages and provided with a breath-in valve (16) originating from the separated space and a breath-out valve (18) exhausting to the atmosphere. The breathable gas feed circuit opens into the space delimited by the head covering. The opening and the breath-in valve are located so that the breathable gas ventilates the head before reaching the breath-in valve (16).



Description

The invention relates to individual breathing equipment for use by personnel who are required to act under hostile surroundings of a nature that requires protection not only for the respiratory passages, but also for the body or at least the entire head. By way of example, mention may be made of equipment for use by firemen who need protection against smoke, and equipment for providing NBC (nuclear, biological, chemical) protection.

Individual equipment are already known comprising a head covering, often reduced to a face-cover with vizor, delimiting the space that is separated from the surroundings and a mask for isolating the respiratory passages, and provided with a breath-in valve and a breath-out valve. The breathable gas may be athmospheric air, sucked in through a filter, when protection is necessary, or it may come from a supply associated with the equipment.

Among the drawbacks suffered by many existing equipment in which the breathable gas penetrates directly into the mask, special attention can be especially given to the fact that the portion of the head enclosed in the covering is not ventilated, which gives rise to discomfort that considerably limits the tolerable wearing time, particularly if the covering contains both the head and the neck.

The present invention seeks to supply breathing equipment of the above-defined type having a covering enclosing the entire head while satisfying practical requirements better than previously known equipment, in particular by enabling the temperature of the chest and the head to be conditioned.

To this end, the present invention provides individual breathing equipment comprising a head covering delimiting a space which is separated from the outside all around the head, and a mask for isolating the respiratory passages, the mask being provided at least with a breath-in valve and with a breath-out valve exhausting directly to the atmosphere, the breathable gas feed circuit opening into the space delimited by the head covering; the location of the outlet from the feed circuit and the location of the breath-in valve for taking air from said space are arranged such that the breathable gas ventilates the head before reaching the breath-in valve. In addition, the equipment is advantageously provided with an additional buffer volume that is placed in the breathable gas feed to said space, said additional volume optionally being defined by a breastplate extending the covering and capable of being integral therewith when the covering is a protecting hood provided with a neck joint.

In this definition, the term "mask" must be interpreted widely as being capable of designating not only a piece covering the mouth and the nose only, but also an assembly constituted by a front portion of the covering and a face joint that includes or constitutes the breath-in valve and that surrounds the nose, the mouth, and generally also the eyes.

With head ventilation ensured in this manner, discomfort is greatly reduced. The

space defined by the covering and the buffer volume acts as an economizer when the gas feed comes from a supply. The lower portion of the breastplate is provided with a coupling for connection to means for feeding it with atmospheric air, generally via a filter installed using an air-tight fast action coupling, or for feeding it with breathable gas coming from a supply, possibly under pressure, and provided with a coupling of the same type.

When a component such as a filter that imposes a head loss that increases rapidly with inflow volume is placed upstream from the deformable buffer volume, the buffer volume considerably reduces volume peaks while breathing-in, and thus reduces breathing fatigue. When the equipment is fed with gas supplied by a source, the presence of the deformable buffer volume makes it possible to reduce considerably the maximum instantaneous flow volume required from the source, for a given mean flow volume.

The mere presence of the breastplate having fresh air or oxygen flowing therethrough serves to remove some of the metabolic heat given off by the chest.

To give the breathable gas an optimal temperature for ventilating the head and for breathing and for removing the heat given off by the chest, a heat exchanger may be provided under the breastplate. It may optionally belong to a jacket having a back that also contains a heat exchanger.

The heat exchanger may be constituted, in particular, by a serpentine array of flexible ducts secured between two sheets of a textile article.

Still in the case where components are placed upstream from the buffer volume that impose a head loss which increases rapidly with flow volume (e.g. a filter) or components for which it is desirable to reduce the instantaneous flow volume (e.g. a blower), the buffer volume is advantageously designed to attenuate flow volume peaks while breathing in by mechanically drawing in gas while the wearer of the equipment is breathing out. It would be possible to place resilient components in a pocket of the breastplate that are compressed when the pocket is flattened under the effect of vacuum due to breathing-in at the end of taking a breath, and that expand the pocket during breathing out thereby drawing in a volume of fresh gas that will be breathed in at the beginning of the next breath. In any event, such components will prevent any clogging.

The invention will be better understood on reading the following description of particular embodiments given as non-limiting examples. The description refers to the accompanying drawings, in which:

Figure 1 is a diagram of equipment constituting one particular embodiment of the invention and fed with atmospheric air through a filter;

Figure 1 bis 3 is a simplified view of the equipment of Figure 1 shown in perspective and without a heat exchanger; Figures 2 and 3 show modified embodiments;

Figure 4 is a curve showing how the pressure that prevails in the mask varies as a function of time, both in a conventional type of installation (solid line curve) and in equipment of the invention (dash-lined curve), in the case of breathing from the atmosphere;

Figure 5 shows equipment that differs from that of Figure 1 in that it is fed with atmospheric air that is compressed by a blower provided with at least one filter;

Figure 6 shows one possible configuration for the heat-removing jacket of Figure 5; and

Figure 7 shows a possible modification of the equipment of Figure 5, enabling breathable gas to be supplied either from the atmosphere or else from a source of oxygen, with or without dilution.

The equipment shown diagrammatically in Figure 1 is designed to be fed with atmospheric air through a protective filter, e.g. an NBC filter. The equipment comprises a flexible head covering 10, provided with a hood with a transparent vizor 12 and with a mask having a gasket that is applied in substantially air-tight manner to the face around the nose and the mouth. A portion of the shell of the mask may be constituted by the front of the hood, or it may be disposed inside the hood.

The covering 10 receives atmospheric air through a filter 14 fixed to a rapid-action coupling and through a deformable buffer volume that enables flow volume peaks through the filter 14 to be reduced. The mask is fed from the space delimited by the hood 10 via a breath-in non-return valve 16. The outlet from the buffer volume into the covering 10 and the valve 16 are arranged in such a manner as to ensure that the air breathed in ventilates the head before reaching the valve 16.

The mask 18 also includes a breath-out valve 18 which opens out directly to the atmosphere so that the space between the covering and the head does not become loaded with water vapor.

In the embodiment shown by way of example in Figure 1, the buffer volume is constituted by a breastplate 20 which performs several functions either separately or simultaneously, depending on the circumstances.

It serves to reduce the flow volume peaks through the filter 14 and therefore to reduce breathing fatigue since pressure losses vary approximately with the square of the instantaneous flow volume when a filter is provided.

The inside face of the breastplate constitutes a heat exchange surface enabling heat to be evacuated from the chest. It can thus be seen that the simple form of the equipment as described above enables heat to be evacuated from the chest, thereby improving comfort, under all conditions and in particular when absence of pollution may make it possible temporarily to do without the filter.

In the particular example shown in Figure 1, comfort is further improved by the inside face of the breastplate being put into contact with a fluid flow heat exchanger (generally liquid flow) that is sufficiently flexible to fit around the chest. The heat exchanger may be constituted, in particular, by a flexible tube constrained to follow a sinuous path between two sheets of cloth. The hydraulic circuit of a heat exchanger 22 constituted in this manner is provided with inlet and outlet nozzles 24 suitable for connecting via a coupling 26 to a liquid conditioning unit 28. The conditioning unit may be constituted, for example, by a circulation pump 30 and by a refrigerator component 32. They receive power from an electrical power cord 34 or from any other appropriate means.

To reduce heating from the ambient atmosphere, the breastplate 20 may be provided with an insulating layer on its outside face. The atmospheric air sucked in through the filter 14 at the base of the breastplate 20 by natural breathing is then cooled prior to reaching this space surrounding the head. When such an exchanger is provided, the equipment has an advantage in surroundings that are not toxic (not requiring a filter) but that are hot or very cold.

The equipment shown diagrammatically in Figure 2, where components corresponding to those shown in Figure 1 are designated by the same reference numerals, includes a mask which is constituted merely by the front portion of the hood, which front portion is separated from the space surrounding the remainder of the head by a face gasket 36 that carries the breathing valve 16 or that constitutes said valve.

In addition, Figure 2 shows a breastplate 20 which contains resilient components 38 that are designed to be compressed by being clamped between the two sheets constituting the breastplate when the pressure inside the breastplate is lower than the atmospheric pressure, and to expand thereafter. These resilient components 38 may be constituted, in particular, by blocks of elastomer material fixed on one of the sheets of the breastplate and regularly distributed thereover. However, this distribution is not essential: the essential point is to avoid clogging by one of the walls pressing completely against the other.

Finally, the equipment shown in Figure 3 differs from that shown in Figure 2 in that the head covering is constituted by a helmet 40 having a movable vizor 42.

When the vizor 42 is down, it is sealingly applied against the front opening in the helmet and constitutes the equivalent of a mask by cooperating with a face joint 36. Under such circumstances, the helmet 40 carries the breath-out valve or valves 18. The helmet may be sealingly fixed to the breastplate 20. The breastplate is provided with a neck gasket 44. The helmet is removably and sealingly connected to the breastplate. The connection may include a sealed ball bearing of known type, but which is advantageous only in conjunction with a compressed oxygen feed, as described below.

The presence of a buffer volume makes it possible to eliminate peaks from the flow volume through the filter 14. In solid lines, Figure 4 shows how the pressure inside the mask varies relative to ambient pressure during cycles of breathing. In conventional equipment, the pressure inside the mask is slightly greater during breathing out, as shown in 46, because of the pressure loss caused by the breath-out valve 18. While breathing in, the suction caused by the breath-in valve 16 and by the head loss through the filter 14 becomes large, as shown by the solid line curve, since the necessary volume of air passes through the cartridge only during periods of breathing-out.

The flow volume peak through the filter 14 is considerably reduced in equipment that includes a breastplate 20 having a large buffer volume; during the initial stage of breathing-in, the breastplate empties such that the volume that needs to be drawn through the filter is smaller.

The amount of underpressure that is required, and thus the amount of breathing effort that is required, can be greatly reduced when the buffer volume is provided with resilient means between its walls, such as the means shown in Figure 2. The resilient means are compressed by the bag collapse caused by atmospheric pressure when breathing-in suction appears. During breathing-out, the resilient components expand and cause the buffer volume to be filled through the cartridge 14. The mean flow volume through the filter then becomes relatively constant. This avoids flow volume peaks and reduces the amount of underpressure, as shown by dashed lines in Figure 4. The presence of such means is not essential in any way. In the option described below where air is fed under pressure by a regulator or by a blower, such means would have an effect only in the event of a failure.

The embodiment shown diagrammatically in Figure 5 (where components corresponding to those described above continue to be given the same reference numerals) is designed to be fed with atmospheric air by a blower. The air inlet of the filter 14 is connected to a feed unit comprising, in succession, a filter cartridge 48, a blower 50 having an electric motor, and a non-return valve 52.

The presence of the breastplate makes it possible for the flow rate required of the blower to be reduced considerably. For example, if the mean flow rate or "ventilation flow rate" is 30 l/mn, then the peak flow rate that would be required of the blower 50 if it were to feed the mask directly, would be about 100 l/mn. However, if the buffer volume is greater than the variation of the lung volume, then the peak can be reduced to 30 l/mn. The power required of the electric drive motor for the blower can be divided by three or the operating time of a given electrical battery can be multiplied by three; the life time of filter cartridges is likewise multiplied by three.

The heat exchanger provided in the equipment of Figure 5 can also remove heat from the back of the wearer if it constitutes a jacket that has the general shape shown in Figure 6, having a back portion in addition to its front portion which is for location between the breastplate 20 and the protective clothing of the wearer, or for location beneath said clothing. Figure 7 shows only the portion that feeds the filter 14 (or the

breastplate directly) in yet another embodiment. The equipment shown in Figure 7 can supply the wearer of the equipment either with atmospheric air (filtered or not filtered), or else with oxygen diluted by atmospheric air, or else with pure oxygen, thereby providing NBC protection. To do this, the duct 54 feeding the filter 14 is branched. One of the branches is fed by the blower and includes a cock 52. The other branch includes a source of oxygen such as a cylinder 56 of oxygen under pressure, and a demand regulator 58, which is provided with a switch for switching it on and off, and for enabling it to provide oxygen that is pure or that is diluted by air drawn via an opening 60 in its housing. To ensure that the air sucked in is itself de-polluted, the air is not taken directly from the atmosphere but from a space that communicates with the atmosphere only via a filter 48. This space may be delimited by a case 62 as described in U.S. patent No. 47 41 332 or European patent No. 1 53 247.

The embodiment of Figure 7 makes it possible to provide NBC protection both when breathing is merely assisted by the blower 50 (with temperature being conditioned by the heat exchanger and with head ventilation being provided by the blower), and when breathing oxygen that is pure or that is diluted. When such protection is not required, the filter 14 and the blower may be omitted.

With simple modifications, the equipment of the invention is capable of providing breathable gas under pressure, e.g. for use in altitude. Under such circumstances, the breath-out valve 16 should be replaced by a compensated breath-out valve and an appropriate regulator of known type should be used.

Under such circumstances, the breastplate has the additional function of pressurizing the chest and it enables a conventional pressurized jacket to be omitted. On such circumstances, the breastplate may be extended over the back and/or over the arms to protect those parts as well.

The equipment described above may be made in the form of modules that can be separated from one another, particularly when the equipment is as shown in Figure 3, the breathing breastplate constitutes a module provided with a coupling for receiving a filter cartridge directly or for receiving a breathing assistance assembly such as that shown in Figure 5. The heat exchanger constitutes an additional equipment for placing beneath the breastplate. It should be observed that the equipment makes it possible to avoid any pipework that opens out directly into the head gear.

Claims

1. Individual protective breathing equipment comprising a head covering (10) provided with a neck gasket and delimiting a space separated from the surroundings all around the head, and a mask isolating the respiratory passages, provided with at least a breath-in valve (16) and with a breath-out valve (18) exhausting to the atmosphere, whereas the breathable gas feed circuit opens into the space delimited by the head covering and the opening and the breath-in valve (16) starting from the separated space are located so that the breathable gas ventilates the head before reaching the breath-in valve (16), **characterized by** a buffer volume that is placed upstream of the opening in said space, said buffer volume being delimited by a breastplate (20) extending the head covering and capable of being integral with the head covering.

2. Equipment according to claim 1 characterized in that the feed circuit is provided with a coupling located on the lower portion of the breastplate that conducts to means for feeding filtered atmospheric air and/or breathable gas, possibly under pressure.

3. Equipment according to claim 2 to characterized in that the feed circuit comprises a blower (50) that can be provided with a filter device placed in an upstream location.

4. Equipment according to claim 2 or 3 characterized in that the feed circuit comprises a source of breathable gas with high pressure (56) and a demand regulator (58).

5. Equipment according to claims 3 and 4 characterized in that the regulator (58) comprises a gas inlet (60) for dilution originating from a space that is located downstream of the blower (50) and is fed by the filter device (48) placed upstream of the blower.

6. Equipment according to claims 1 to 5 characterized by a heat exchanger (22) located under the breastplate.

7. Equipment according to claim 6 characterized in that the heat exchanger (22) is a component of a jacket that can also comprise a back portion which contacts the back of the wearer and which is fed through a device (28) for circulating a cooling or heating fluid.

8. Equipment according to one of the claims 1 to 7 characterized in that the breastplate (20) comprises distributed resilient components (38) that can be compressed by breathing-in from the atmosphere.

9. Equipment according to one of the preceding claims characterized in that the head covering (10) is defined by a hood comprising a neck gasket or by a helmet (40) that is sealingly connected at least to the front part of the clothing covering the chest.

10. Equipment according to one of the preceding claims characterized in that the breastplate is part of a clothing for pressure admission of the chest and possibly the arms.

Accompanied by 3 page(s) of drawings

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FIG.2.

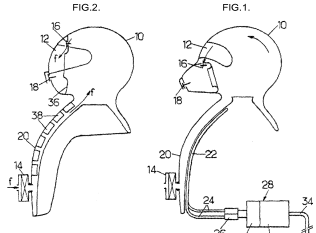

FIG.1.

FIG.4.

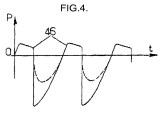

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FIG.1bis

FIG.3.

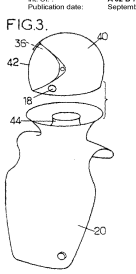

FIG.7.

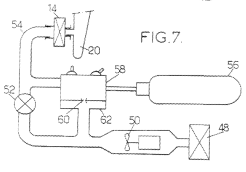

FIG. 5.

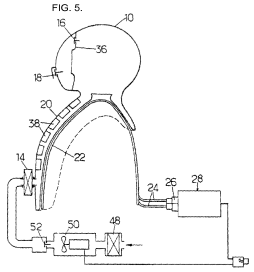

FIG. 6.